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**FIELD OPERATIONS AND OCEAN-BOTTOM
SEISMOGRAPH PERFORMANCE AND EVALUATION
KURILE ISLANDS EXPERIMENT**

Special Report No. 1

OCEAN-BOTTOM SEISMOGRAPHIC EXPERIMENTS

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ABSTRACT

A shallow-water test program and a deep-water operational program were conducted. The shallow-water tests environmentally checked the performance of 14 units which were not tested under the previous contract. Special tests of antenna design and temperature measurements were included. Of the 14 units checked, 13 were either fully operational or required minor corrections. One unit surfaced prematurely, floated inshore and was damaged on the rocks. The unit is being repaired under a new contract.

Deep-water tests were conducted adjacent to the Kurile Islands Arc to evaluate the seismicity of the area and the operational worthiness of the O. B. Seis and auxiliary equipment. Results of the seismicity study are summarized in a bulletin which is presented separately. The worthiness of the units was proved by the volume of the data recorded. Of 18 units dropped, 14 were recovered; of the 14 recovered, 13 recorded for all or most of the time. The one unit which did not record was dropped to a depth greater than design specifications. The great pressure permanently distorted the sphere, pushing the shell against the recorder to prevent operation. However, this unit can be repaired. In general the auxiliary equipment performed to manufacturers' specifications. The greatest problems were caused by the weather and the area of operations.



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SECTION I

INTRODUCTION

During the fall of 1966, an Ocean-Bottom Seismograph experiment was conducted near the Kurile Islands to evaluate the seismicity of the area and operational worthiness of instrumentation. Field exercises for the experiment included:

- Task I - Shallow Water Tests - California
- Task II - Field Operations - Kurile Islands

This report includes a description of the field operations and of techniques performed during both Tasks I and II. It also describes some of the problems encountered and evaluates both the Ocean-Bottom Seismograph and the auxiliary equipment.

A. TASK I - SHALLOW WATER TESTS

Under Task I, 14 units not tested under an earlier contract were evaluated. Checks were run on all units and all malfunctions were corrected. A special test involved a study of antenna design and resulted in the adoption of the JT No. 2 antenna for all units. Table 1 is a summary of the performance of each O. B. Seis unit during the shallow drops.

B. TASK II - FIELD OPERATIONS

The field operation along the Kurile Trench included a study of ocean-bottom network installation, data collection, network calibration, and instrument orientation using chemical explosions.



TABLE I

SUMMARY OF THE PERFORMANCE OF EACH
OCEAN-BOTTOM SEISMOGRAPH UNIT - SHALLOW DROPS
(Testing Period - 3-21 September 1966)

Unit No.	Date	Recovery	Electrical	Mechanical	Other
1*	Sept. 14-15	Sonar 15 sec.	o. k.	Tape did not pull	Regular 48" upright antenna
2	Sept. 6-7	Sonar 4 min.	o. k.	o. k.	J. T. No. 1 antenna
5	Sept. 9-10	Sonar 8 min.	o. k.	o. k.	J. T. No. 1 antenna
10	Sept. 12-13	Sonar 17 sec.	o. k.	o. k.	J. T. No. 2 antenna
11	Sept. 10-11	Sonar 1 min.	o. k.	Anchor line buoy pulled approx. 15' under	Regular 48" upright antenna
12	Sept. 11-12	Sonar 15 sec.	o. k.	o. k.	No antenna
13*	Sept. 14-15	Sonar 2 min. 45 sec.	o. k.	o. k.	J. T. No. 2 antenna
14*	Sept. 8-9	Sonar 2 min.	o. k.	o. k.	J. T. No. 1 antenna
16	Sept. 7-8	Sonar 2 min.	o. k.	o. k.	J. T. No. 1 antenna
18	Sept. 13-14	Unit surfaced before recall.	Reason unknown.		Regular 48" antenna
19	Sept. 4-5	Sonar 1 min.	o. k.	o. k.	J. T. No. 1 antenna
21*	Sept. 15-16	Sonar 8 min. 13 sec.	o. k.	Antenna did not erect	Jack-in-Box antenna
23*	Sept. 12-13	Sonar 3 min. 25 sec.	o. k.	o. k.	8" wire antenna
25	Sept. 9-10	Sonar 2 min.	o. k.	o. k.	8" wire antenna

- * Unit 1, Sept. 18-19 - Tape recorder pulled tape in warehouse.
Unit 13, Sept. 16 - Dropped with Rustrak Temperature Recorder.
Unit 14, Sept. 6 - Surfaced prematurely due to "O" ring leak.
Unit 23, Sept. 8-9 - Regular antenna. Tape recorder did not pull tape.
Sept. 10-11 - Set for one day on Bulova clock. Surfaced at 1 day, 2 hours, 22 minutes. J. T. No. 2 antenna partly erected. Tape recorder did not pull tape.
Unit 21, Sept. 5-6 - J. T. No. 1 antenna. Clock showed some drift.



SECTION II

TASK I - SHALLOW WATER TESTS

A. OBJECTIVE

The objective of the shallow water tests was to evaluate the 14 units not tested under Contract No. AF 19(628)-5890. Shallow water tests were performed at Santa Barbara, California. All tests were made in water depths of 50 to 200 feet.

Specific purposes of the tests were to check for:

- Water tight seal
- Leveling ability of the seismometer package
- Response of all amplifiers and seismometers to noise signals
- Operation of tape recorder when sealed
- Accuracy of digital clock
- Operation of sonar recall
- Operation of radio beacon transmitter
- Operation of beacon lights
- Results of other special tests, such as Bulova back-up recall and tests of various antenna designs and antenna mounts

B. OPERATIONS

The M/V Calcasieu, owned by General Marine Transport of Santa Barbara, was used for this operation (Figure 1). A track-mounted mobile crane was placed aboard to facilitate launching and retrieval of O. B. Seis units (Figure 2). Also installed on deck and located where the cat-head could be used to retrieve the anchors was the Nova winch. The only other necessary equipment on board was the sonar transmitter cabinet and the sonar transducer.

Operational procedure was as follows:

- Check out, start, and seal each unit in the warehouse
- Transfer each unit to the deck of the Calcasieu
- Proceed to the drop site - 80 to 200 feet depth
- Tie rope and float to the anchor (Figure 3)



Figure 1. M/V Calcasieu



Figure 2. Track-Mounted Crane



- Lift unit overboard and release it
- Leave unit on ocean bottom for 24 hours
- Recall unit by sonar
- Retrieve O. B. Seis unit
- Retrieve float, rope, and anchor
- Return unit to warehouse
- Open and analyze unit for proper operation



Figure 3. Rope and Float Tied to Anchor

C. SUMMARY

The shallow water tests were finished on schedule. All defects detected during the tests were corrected. In addition, some special tests were added, including dropping a unit with a Rustrak dual-channel recorder inside in order to record the temperature of both the inside surface of the sphere and the digital clock crystal. The specific objective of this test was to provide temperature information to assess clock drift. This test showed that the crystal temperature lags the sphere temperature change by about one hour.



Another of the special tests involved a study of antenna design. It was suspected that the antenna might be contributing to the spurious resonant signals often evident on the records. Tests were made with various antennas including:

- Regular 48-inch fiberglass upright antenna
- JT No. 1 48-inch spring-loaded hinged antenna
- JT No. 2 variation of JT No. 1
- "Jack-in-box" pop-up 96-inch antenna
- Bare wire 8-inch antenna
- No antenna

These tests with the various antenna designs indicated that the most mechanically reliable design and the design contributing least to unwanted motion of the O.B. Seis unit was the JT No. 2. This antenna consisted of a 48-inch fiberglass whip mounted on a hinged spring mounting plate. On the ocean bottom, the mounting hinge allows the full length of the antenna to lie flush against the side of the sphere. When the anchor weight is released, the spring within the hinge pops the antenna to the upright position and holds it there. This design was adopted and all O.B. Seis units equipped with this type of antenna.

Corrective measures taken for malfunctions which occurred included:

- Correcting tape pull. On one unit (No. 1) the reel was rubbing against the radio beacon transmitter; on another unit (No. 23) the tape drive had to be adjusted
- Replacing a defective O-ring (unit No. 14) to correct for a salt water leak
- Returning a digital clock (No. 21) that was out of tolerance to the Dallas lab for corrective maintenance
- Double-checking all sonar recalls that seemed slow to respond (Unit No. 2, 5, 21, and 23)

In addition, one unit (No. 18) was damaged when it surfaced prematurely and floated inshore onto the rocks. Salt water leakage is suspected as the reason for the premature surfacing. This unit could be used only for spare parts during the balance of the 1966 program. The unit is being repaired and will be available for future programs.



SECTION III

TASK II - FIELD OPERATIONS

During the time that the shallow tests were being conducted, two ships were being outfitted in Morgan City, Louisiana, for a major field operation. This field operation was conducted along the Kurile Trench and adjacent to the Kurile Islands during the months of October, November, and December, 1966. The field operation could be broken down into two major phases:

- Ocean-bottom array installation and data collection
- Network calibration and instrument orientation using chemical explosions

Since the calibration program was a major phase of the total operations and the techniques developed for handling the charges have future use, Special Report No. 2 was written to describe the calibration program in detail.

A. PREPARATION

Two ships with crews were chartered from Falgout Boats, Incorporated of Galveston, Texas. These boats were the 156 foot M/V Pacific Seal (Figure 4) and the 165 foot M/V Campeche Seal (Figure 5). The boats were essentially the same in design and performance. They were designed primarily for servicing offshore oil rigs in the Gulf of Mexico and have the house forward with approximately 110 feet of clear aft deck.

General specifications of the boats were:

- Lengths of 156 and 165 feet
- Beam approximately 38 to 40 feet
- Approximately 299 gross tons
- Draft 7 to 9 feet
- Twin screw
- Power twin Caterpillar Model D398-A
- Sperry gyro compass with autopilot
- Full bridge control
- Radar
- AM marine radio
- SSB communications transceivers



Figure 4. M/V Pacific Seal



Figure 5. M/V Campeche Seal



- Fathometer (inshore)
- Speed 11 knots
- Range in excess of 5,000 miles
- Crew 9 men on 24-hour operation
- Accommodations 17 men, including crew

To prepare the boats for the operation, it was necessary to add storage space, handling equipment, and various pieces of electronic gear. Included in the rigging of the ships were:

- Adding a 45 foot x 25 foot instrument house to the M/V Pacific Seal
- Adding a 25 foot x 15 foot instrument house to the M/V Campeche Seal
- Mounting a heavy duty hydraulic crane on the stern of each vessel
- Installing an Ocean Sonics, Inc. model GDR-T fathometer in each vessel
- Mounting various antennas for receiving WWV, radio beacon direction finder, D-X Navigator, and other communication antennas for direct contact with military channels in Japan
- Installing D-X Navigator (Loran A and C receiver) equipment aboard both vessels
- Installing Omega navigation system with antenna aboard the M/V Pacific Seal
- Installing special handling gear on the M/V Campeche Seal, e.g., the launch slide for the calibration shots

Prefabricated material purchased from American Buildings was used to construct the two instrument houses on deck (Figure 6). They were constructed so that they could be cut loose and removed from the deck of the ship after completion of the operations. The floor level was about 2 feet above deck level in order to keep out the deck wash. Tracks were welded to the floor to facilitate placement and movement of the O. B. Seis units. Each house was equipped with a turn-table on slides to enable the O. B. Seis units to be moved in and out of the house (Figure 7). The larger house could accommodate 18 O. B. Seis units and the smaller house 5 units. Overhead hand-operated chain hoists on traveling blocks were mounted where they could be used to lift covers wherever necessary. To each house was added storage space, work benches, lights, power outlets, and electric heaters.

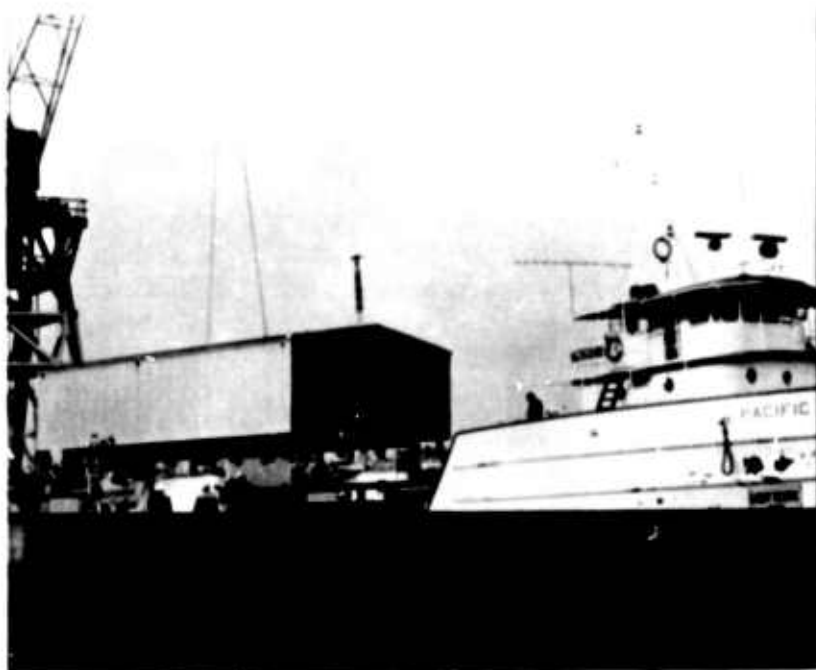


Figure 6. Instrument House (Being Off-Loaded)



Figure 7. Turn-Table and Slides



Hydraulic cranes were mounted on the starboard stern quarter of the ships so that they could reach out over either the stern or the starboard side of the ship (Figure 8). When extended, the boom could reach out 35 feet. The wheels of the cranes were removed and the units were welded to the deck. On each, a cat-head, which was used to move the turn table in and out of the house, was attached to the left front hub. Cranes used were a Galion Model C-110 on the M/V Pacific Seal, and an A-W Model 410 on the M/V Campeche Seal.

Mounted in the wheelhouse were the fathometers, D-X Navigators, and RDF equipment. However, due to space limitations, the Omega navigation system was set up in one stateroom and the special military communications gear was set up in another stateroom.

Houses and cranes were rigged in Morgan City, Louisiana, while fathometers, D-X navigators and Omega were rigged in San Pedro, California.

After completion of rigging, the M/V Campeche Seal moved to the Naval Weapons Station at Seal Beach, California, where it took on its cargo of 60 tons of Composition B explosive, plus caps, boosters, and primers. At the same time, the M/V Pacific Seal moved to Santa Barbara, California, where 18 O.B. Seis units and all the support gear were loaded aboard.

On 27 September 1966 the ships departed together enroute to Kushiro, Japan. They arrived in Kushiro on 16 October. Work was immediately begun to ready the ships for the start of operations.

B. OPERATIONS

On 21 October 1966, both ships left Kushiro enroute to the operations site. Figure 9 shows the site of operations.

Daily reports from the ships, monthly reports, and other special reports have recorded in detail the actual operations statistics. Figure 10 shows the recording periods and statistics and summarizes the instrument performances. Additional details of seismic results are not included in this report. This report describes some of the operational techniques and problems, plus an evaluation of both the O.B. Seis units and auxiliary equipment.

As the ships approached the location of the intended seismic station, the O.B. Seis unit was prepared for drop. Each unit's cover was removed and a complete system checkout was completed on every subsystem. Complete written records were made of all voltage readings and of the step by step checks. After all units were in full operation condition, power was turned on, WWV (or JJY in Japan) was tuned in, and clock reset was made.



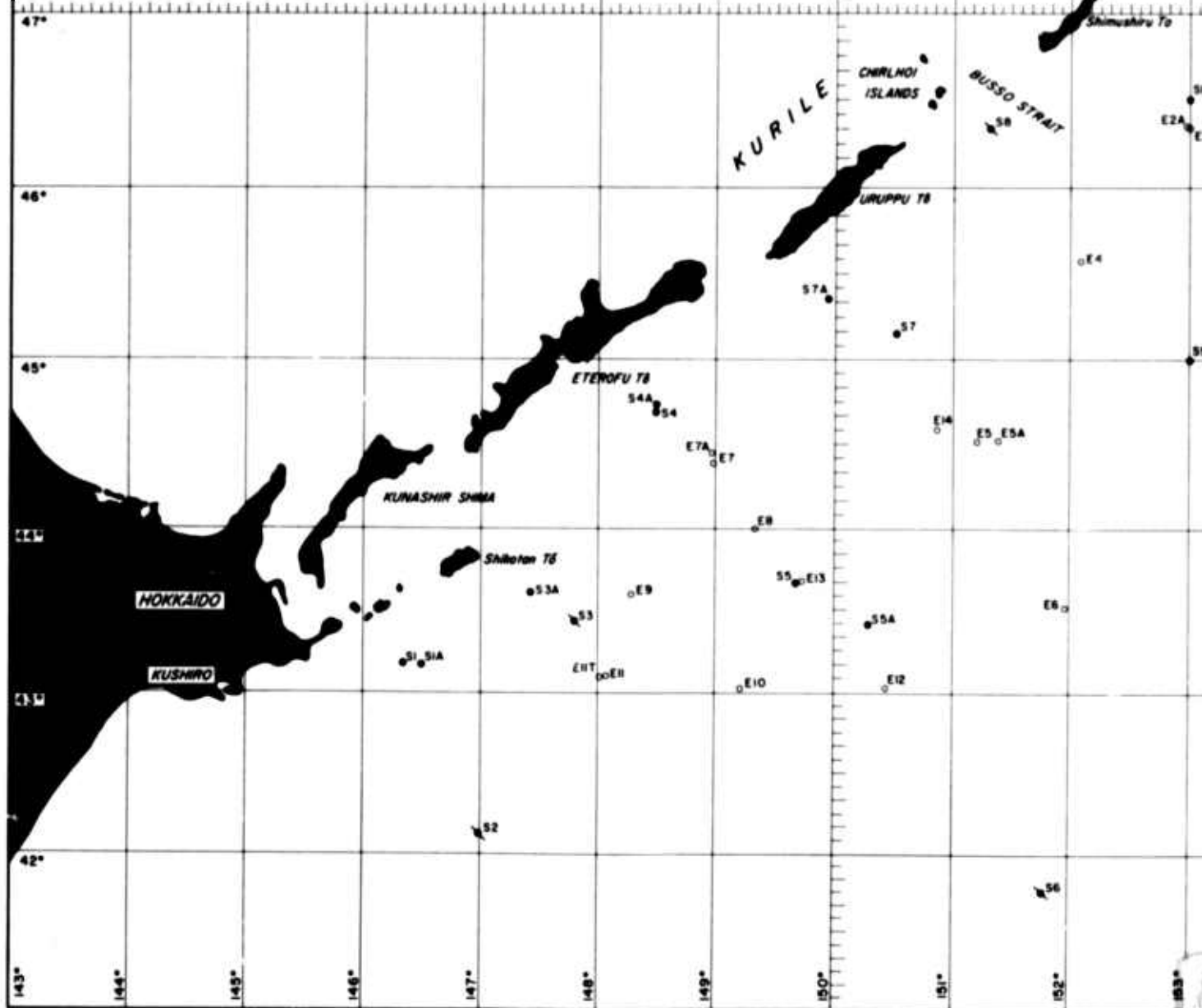
Figure 8. Hydraulic Crane

EVENT AND SYSTEM LOCATION CHART
KURILE ISLANDS
NORTH PACIFIC OCEAN

MERCATOR PROJECTION
SCALE: Based on Lat. 52° 30'

LEGEND:

- CALIBRATION EXPLOSION LOCATION
- SYSTEM LOCATION
- ↘ UNRECOVERED SYSTEM



Fig

1

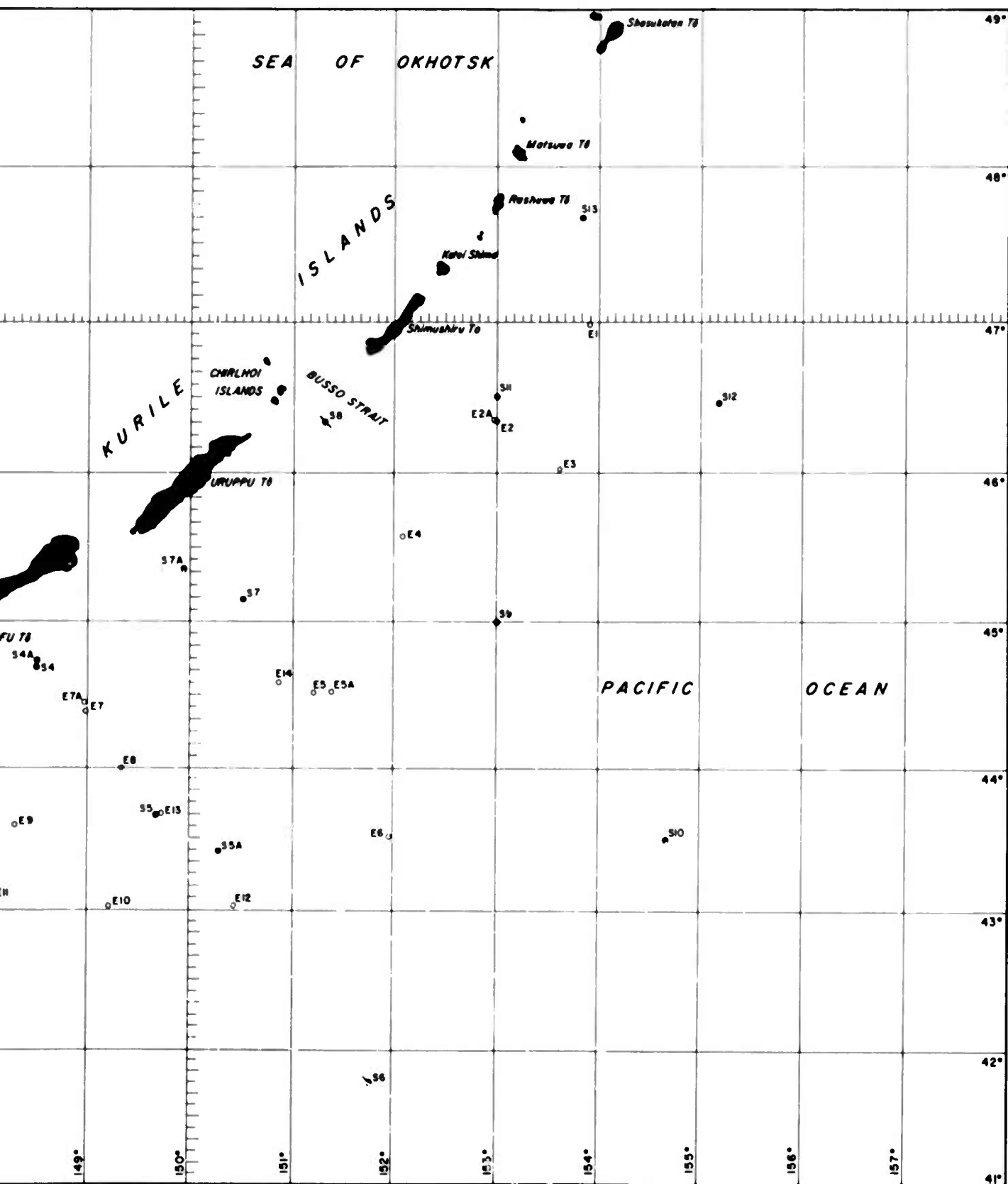


Figure 9. Site of Operations

III-7/8



Unit No.	Pos.	Record Data (days)	Days on Bottom	No. Channels Recorded	Instrument Performance							Beacon Light
					Amp System	Recorder	Clock Drift (sec)	Recall		Radio Tx		
								Sonar	Clock			
21	1	13	36	9	X	BF	+0.7	X		X	X	
16	4	29	31	9	X	X	—	X		F	X	
15	5	—	31	—	X	X	—	X		X	F	
19	7	30	30	9	X	X	-5.3	X		X	F	
20	9	29	30	9	X	X	-0.1	X		F	X	
13	10	28	40	12	X	X	—	NA	X	X	F	
22	11	27	40	6	X	X	+0.3	F	X	X	F	
25	12	14	20	9	X	BF	+0.7	X		X	X	
24	13	19	20	9	X	X	-1.1	X		X	F	
19	1A	16	17	12	X	X	0	X		X	X	
20	3A	6	17	9	X	BF	-3.0	X		X	X	
10	4A	17	18	12	X	X	+0.2	X		X	X	
21	5A	9	10	12	X	X	+0.9	NA	X	X	F	
24	7A	17	17	9	X	X	+0.3	X		X	X	

Note: X indicates satisfactory performance.

BF indicates battery failure.

NA indicates sonar recovery not attempted.

F indicates particular subsystem failed to function.

Unit 15 failed to operate due to excessive depth.

Figure 10. Summary of Instrument Performance



See Appendix A. JJY time was immediately written on the data sheet. After recording JJY for 10 minutes or longer, as necessary to record some good signal, another visual check was made of all switches, plug-ins, and tape travel before putting the cover on the unit. The unit was then sealed, partially evacuated, and the beacon light, antenna, and bale were secured in place. The unit was then moved to a position outside the house where it could be reached by the crane (Figure 11).

When notified by the captain or navigator that the ship was over location, the ship was headed slowly ahead with the seas. The crane operator at this time lifted the unit clear and swung it over the side of the ship. To help steady the unit, generally three tag lines were attached to the unit until it was ready to be lowered into the water. When all lines were clear, the safety pin was pulled and the unit lowered into the water. As soon as the unit was submerged, the quick release hook was pulled and the unit was free to fall to the bottom.

Recovery was in the reverse sequence. The ship was maneuvered close enough to the unit to snap the crane cable into the bale. As soon as the unit was hooked, the ship was turned stern into the sea in which position the ship was most stable. As soon as the unit cleared the water, it was brought along side and close enough to the rail that a couple of tag lines could be snapped on. The unit was swung aboard and dropped onto an anchor which was already assembled.

The unit was then moved into position in the instrument house. After opening, JJY time was again recorded. Also, all times, voltages, and any information that might be of interest at a later date were recorded on the data sheet.

Most of the problems during field operations were caused by bad weather conditions. Although some supply problems were encountered, the cooperation of various agencies minimized these problems.

C. PERSONNEL

In addition to the regular ships crew, each vessel carried a representative of the United States Government and five engineers or engineering technicians from Texas Instruments Incorporated. Fortunately, at least one Japanese scientist was always aboard one vessel or the other. These gentlemen were very helpful, both aboard ship and with language problems ashore. Their cooperation and assistance in obtaining weather information was especially valuable to our operations.

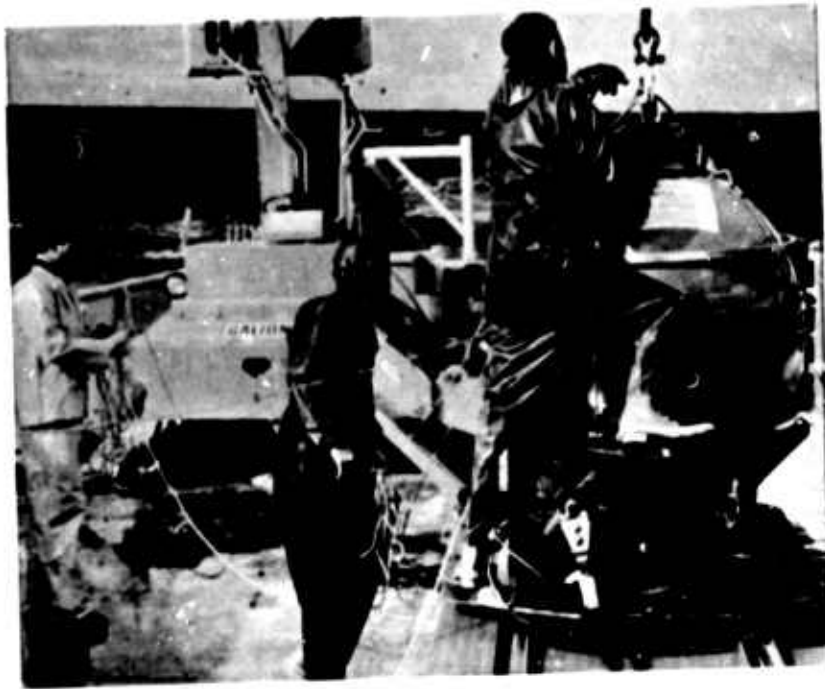


Figure 11. O. B. Seis Ready for Drop



SECTION IV

NAVIGATION

In the Kurile area, navigational accuracy was expected to be difficult. Using a combination of all available means of navigation gave an accuracy of ± 2 miles for the major portion of the program. This accuracy quickly degenerated when weather was bad and celestial fixes were unobtainable.

Means and methods of navigation were:

- Dead reckoning
- Radar
- Celestial (extant)
- Loran (both A and C)
- Omega VLF navigation system

Dead reckoning is the basic means of navigation. All other aids to navigation must conform to a reasonable dead reckoning position or be treated with doubtful credibility. Dead reckoning depends upon the prediction of true speed, course, and drift, and its accuracy is inversely proportional to time. The two ships used gave quite predictable results in calm weather; however, rough seas made it very difficult to compute an accurate dead reckoning course.

Radar was very useful in the area close to the Kurile Islands. Since most of the islands rise steeply out of the water, they made a good radar target. It was quite simple to come close enough to the islands (12 to 15 miles) to get a radar fix and then move to a drop location or a shot point.

Celestial navigation was the most reliable and most used method during the entire operation. Fixes could be taken twice per day (dusk and dawn) and fairly good speed and dead reckoning obtained from a series of sun shots. However, it has been estimated that during the months of October through December in the Kurile area celestial navigation is possible only 50 percent of the time.

Loran C has a range in excess of 1,500 miles, with an accuracy of about 1 foot per mile. Loran C is much more accurate than Loran A. There are three Loran C networks in the Pacific, with the Western Pacific network within the 1,500 mile radius. However, all the signals from the Western Pacific network were coming from the same general direction, resulting in signals close to the base line extension and, therefore, giving poor fix information.



Loran A was of some assistance in the southern part of the operational area. All the Loran A stations used were located on either Honshu or Hokkaido. Range of dependable Loran A is generally limited to 300 or 400 miles, with an accuracy of about 1 mile per 100 miles. As operations moved north, the signal became weaker and the signals became closer to the base line extension.

Each ship was equipped with a D-X navigator which is a combination Loran A and C receiver. The Loran A section of the receiver worked very well, but the Loran C section of the receiver was inadequate for reliable Loran C navigation. The Loran C section was only capable of Loran A accuracy, even when receiving Loran C signals and did not seem capable of receiving and synchronizing to Loran C signals. Operation of the receiver on Loran C allowed the operator to calculate, at best, one Loran C reading at a time. A more accurate Loran C receiver, e. g., Sperry Gyroscope or equivalent, would be able to do the following:

- Track automatically and continuously
- Give two simultaneous readouts of hyperbolic chart readings which result in a fix of position
- Be completely automatic in normal operation making it easy to determine a position

Loran accuracy is dependent on the radio propagation paths. For greatest accuracy, the ground wave must be used; all charts are plotted using the ground wave propagation path. During the night, the signals follow sky wave paths, making corrections necessary. While these corrections are shown on charts, the corrections are averages and interpolations made from a few readings. During the field operations, the ground wave was received for approximately 8 hours out of every 24. The far northern position of the Kurile area and the time of year did not contribute to Loran navigational accuracy.

An Omega-VLF navigation system was installed experimentally aboard the M/V Pacific Seal. In theory, a network of eight Omega stations around the world should give a navigational fix accuracy of 0.25 miles anywhere in the world. In practice, only three stations are now in operation, plus one experimental station operating on very reduced power. Best results were obtained by using two Omega stations, plus one VLF station. The three stations chosen were Omega Haiku (located in Hawaii), Omega Aldra (located in Norway), and VLF station NPG (located in the state of Washington). These three stations gave a good three-line fix when using the Range-Range-Range method of navigation.

The Omega navigational system is based on the principal of phase



detection of a very accurately timed pulse from a very low frequency transmitter. Omega stations operate at both 10.2 kcps and 13.6 kcps. Pulses of these frequencies are sequentially transmitted from the Omega stations. All Omega stations are phase locked together and all are controlled by a common, very accurate timing standard. The Omega receiver must be capable of maintaining very accurate time and of measuring phase differences of 0.1 microsecond. A "lane-count" is maintained by the receiver as long as the signal is not interrupted. The receiver is also designed to tune to any VLF station operating between 10 and 30 kcps. The Omega receiver itself was reliable.

Most problems with the Omega system were caused by the transmitting stations. Some of the problems encountered were:

- Omega transmitting stations off the air for extended periods
- VLF transmitting station subject to large time drift
- Transmitting stations occasionally correcting their clocks, but doing this unknown to the ships Omega operator
- Continually changing diurnal corrections. The corrections could only be obtained by readings made while in port

In addition, the received signal was corrupted by communication transmitters onboard the ship. If these transmitters were on for long periods, it was possible to lose "lane-count." Also, a vertical whip antenna was broken off during a storm and the signal was lost until the storm was over (two days).

Although the Omega system was not used for navigation during the Kurile Island program, it was kept running throughout the program and a data sheet or chart entries were posted daily. No attempt has been made to use this information to reconstruct the ship's position. Information is available for each transmitting station giving time deviations, corrections, and off-the-air times. Appendix B is taken from a report on Omega station operations for the period from 15 November to 31 December 1966. A similar report for VLF station-NPG should be available.

While the Omega system is not now dependable because of the transmitting stations, its possibilities are very attractive. Until a satellite navigation system comes into use, the Omega system could be the most accurate navigation system available.



SECTION V

PROBLEMS ENCOUNTERED

A. WEATHER

More problems were caused either directly or indirectly by bad weather than by any other factor. Storms are commonplace (every three or four days) in this particular geographic area, sometimes causing interruption or delays in the operations.

The ships were designed primarily for supplying oil rigs in the Gulf of Mexico. The hull design made it impossible to hold both a true course and full speed in the face of a storm. When the speed was cut, drift could become an error factor. Navigation and ship's location were also hindered by the loss of sextant readings of the sun and stars during storms. Heavy seas caused the ships to pound, making it necessary to either change course or to cut speed.

By properly maneuvering the ship, it was possible to launch or retrieve a unit in 20 to 25 foot seas. However, this maneuvering often caused dead reckoning accuracy to be lost at a time when because of weather conditions dead reckoning was the only type of navigation available.

The weather also affected communications, both ship to ship and ship to shore, especially during periods of intense storm.

B. SUPPLIES

Thanks to the cooperation of our Japanese shipping agent, the local government agencies, the office of the Science Attache' of the American Embassy, the U. S. Far East Forces Communication network and the TI Tokyo Office, supply problems were minimized. Of course, when spare parts must be ordered from the United States, a time delay is involved.

Procurement of the correct grade of diesel fuel oil was a problem throughout the operations. The ships normally use standard grade diesel fuel (designated Diesel No. 2), but this was unavailable in Japan. The fuel grade above Diesel No. 2, called "gas diesel," was quite similar to kerosene and burned somewhat hotter than Diesel No. 2. The grade below contained considerably more heavy oil and was roughly equivalent to standard bunker fuel. The chief engineer was hesitant to use the heavier fuel for fear of clogging all his filters and injection tips. At the last port of call in Tokyo, the fuel company agreed to mix a special blend, consisting of 83 percent gas diesel and 17 percent bunker oil, for our use. Since troubles still continued, the general conclusion was that the two fuels were



not properly mixed, causing the ship receiving fuel from the bottom of the delivery barge to take on an excessive amount of the heavy bunker fuel. This ship did in fact have extreme filter problems and had to stop in Honolulu enroute home to take on additional filters and change fuel. Also, during the field tests some time was lost when both ships ran on only one engine for short periods of time.

C. LARGE DISTANCES BETWEEN STATIONS

One recognized difficulty was the large distances between stations and the overall size of the area of operations. Even though two ships were involved, the scope of operations and the number of both seismic stations and calibration stations attempted meant a large amount of travel time.

Eighteen units were dropped over a widely dispersed area. The ships were generally outside of radio beacon range when a unit surfaced prematurely.

D. COMMUNICATIONS

Communications were affected by the weather. Contributing also to the communications problem were such things as critical distances, propagation paths, time of day, and general atmospheric conditions. JY reception was affected by these source phenomena making it difficult to receive a clear time signal at certain periods.



SECTION VI

EVALUATION OF THE OCEAN-BOTTOM SEISMOGRAPH AND AUXILIARY EQUIPMENT

A. OCEAN-BOTTOM SEISMOGRAPH

The O. B. Seis units were reliable as self-contained, free fall remote recall, deep ocean instrument packages and gave reliable data. The ability of the units to detect and record seismic energy is readily evident from a study of the bulletin and its accompanying report.

Eighteen units were dropped during the Kurile program. Of these, 14 were retrieved - a very successful retrieval ratio considering the many hostile forces (weather, widely dispersed stations, sometimes questionable navigational accuracy, and an unknown sea floor).

An additional five units were dropped by the Campeche Seal during the first phase of operations. All five units resurfaced almost immediately due to salt water leakage. Of these five units, two were later redropped and operated successfully (No. 10 and 13). No. 5 was damaged during recovery and not redropped. No. 2 was redropped and again leaked salt water. No. 11 was redropped and never recovered.

Figure 12 gives a summary of the instrument performance as observed from film. All units recovered, with the exception of Unit 15, recorded during a high percentage of the bottom time. Appendix C diagrammatically illustrates each unit's position from reset time to opening and Figure 13 is a bargraph of each unit's recording period and also shows explosion sequences.

All subsystems of Unit 15 were working perfectly at the time it was dropped. However, Unit 15 was dropped to a depth greater than 25,000 feet which is greater than design specifications. A critical survey of the retrieved unit disclosed the following:

- The complete sphere was compressed beyond its elastic limit, taking on a permanent shrink. It was necessary to apply compressed air pressure to blow the unit open and at least 0.005 inches must be machined from both sides of the pressure ring before it can be reassembled
- A permanent dimple rings the upper hemisphere at the 45 degree chord
- The radio transmitter was compressed against the recorder, thus accounting for the fact that no tape ran and no data were recorded

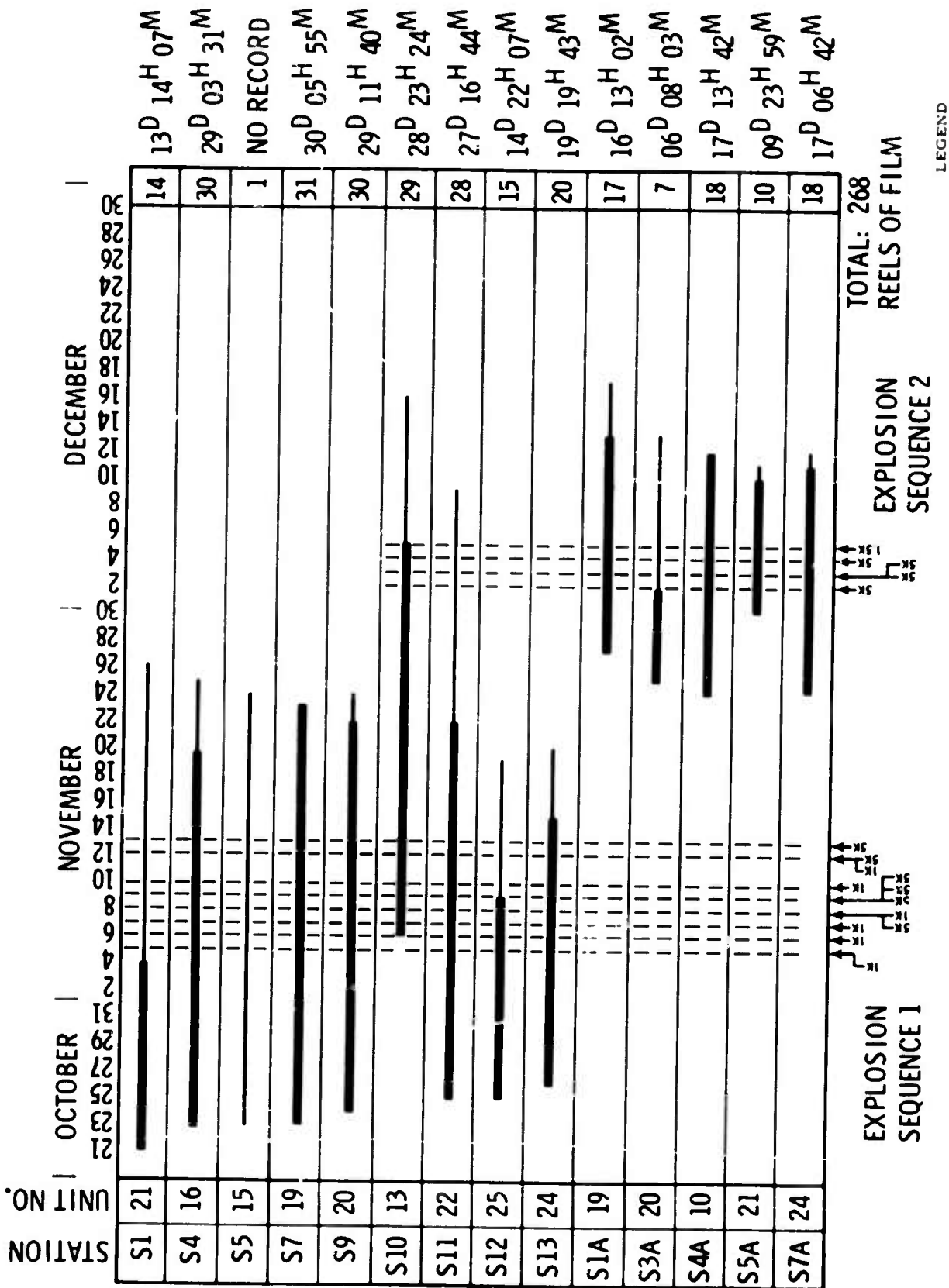


Figure 12. Summary of Instruments as Observed from Film



Unit/Pos	Percentage of Time: Pressure Operational	Percentage of Time: Vertical Operational	Percentage of Time: Horizontal 1 Operational	Percentage of Time: Horizontal 2 Operational	Clock Trace Data		
					Amplitude Consistent	Time Code Continuous	Ability To Read Time at End of Data
10-4A	100	100	90	90	X	X	Good
13-10	100	100	100	100	O	X	Poor
16-4	100	100	0	100	O	O	Poor
19-7	100	100	100	0	X	X	Good
19-1A	100	100	90	90	X	X	Good
20-9	100	100	0	100	X	X	Good
20-3A	100	100	100	10	O	X	Poor
21-1	35	100	100	100	O	X	Poor
21-5A	100	100	100	90	X	X	Good
22-11	100	100	0	0	O	X	Poor
24-13	100	100	0	100	X	X	Good
24-7A	100	100	25	55	X	X	Good
25-12	100	100	100	0	O	X	Poor

Note: Operational performance figures indicate percentage of time a particular component was operating, allowing 3 hr after arrival on bottom for the seismometer to stabilize.

Amplitude of clock pulses refers to amplitude of each 1-sec pulse: X = Normal; O = Poor.

Continuous time code refers to chronological order output of time coded pulses: X = Normal; O = Poor.

Inability to read time code at end of data due to reduced speed of recorder as a result of low battery voltage.

Figure 13. Recording Periods - Kurile Islands Experiment



After units were returned to Dallas, an analysis of each unit was made (reported in Monthly Report No. 6). As a result of this study and after careful consideration of all problems, a proposal was prepared and submitted (TI Proposal No. 118-SSD67). The rehabilitation and design changes proposed should result in 14 highly dependable, field worthy ocean-bottom seismographs.

B. AUXILIARY EQUIPMENT

1. Navigation

Section IV of this report discusses the advantages and disadvantages of the various means of navigation.

2. Communications

Communications equipment and operations were thoroughly reviewed in a memo by Walter T. Peterson. This review is included as Appendix D.

3. Fathometers

Two Ocean Sonics, Inc., Model GDR-T Precision Sonar Recorder and Transceivers were purchased and installed aboard the M/V Pacific Seal and M/V Campeche Seal. The GDR-T includes a 19-inch chart recorder and an integral sonar transceiver (Figure 14), which was coupled to an Edo pierced lobe transducer. Both systems were capable of recording depths in excess of 4,000 fathoms and, by a proper selection of automatic programming, the chart scanning rates could be varied from 20 to 2,000 fathoms. Paper feed speed was automatically adjusted to suit each scan rate.

During the Kurile operations, the fathometer aboard the M/V Campeche Seal charted most of the cruises of that vessel. Bottom profile maps computed from this data are given in Special Report No. 3.

The unit aboard the M/V Pacific Seal would only operate to depths of a few hundred fathoms. During the last month of operations, this unit was shut down and parts removed to supply the necessary spares for the other unit.

When operating properly, the GDR-T was an excellent echo sounder. However, break-down and maintenance time required to keep the equipment operable must be considered excessive. Most of the troubles were traced to the printed circuit boards, and consisted of both component failures and some poor workmanship in the soldering and assembly of the boards. These problems have been made known to the manufacturer and he requested that both systems be sent to the factory for a complete overhaul and checkout.

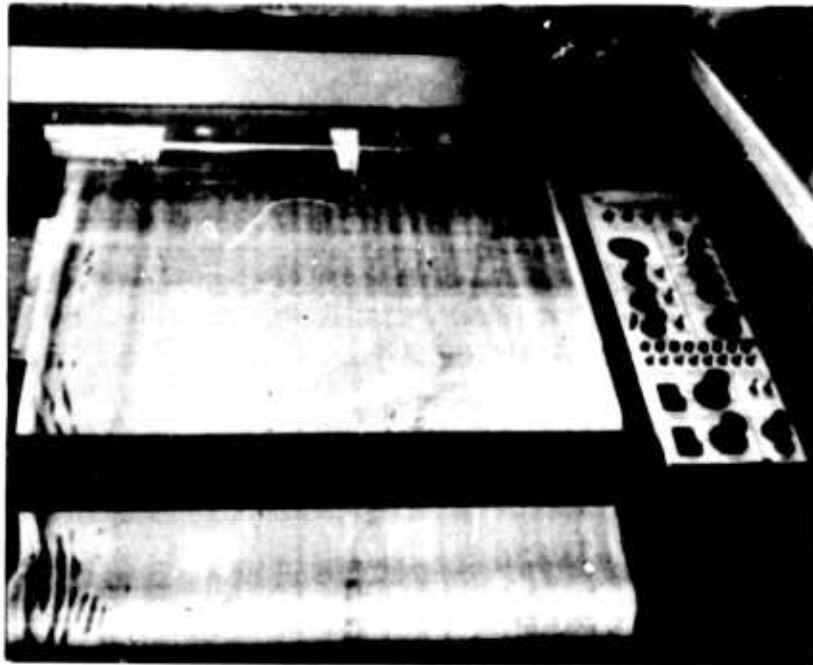


Figure 14. GDR-T Precision Sonar



APPENDIX A

**OCEAN-BOTTOM SEISMOMETER
PREPARATION AND LAUNCH DATA**

Date Launched 10-21-66Sphere No. 21Date Retrieved 11-27-66Clock No. 21Position 1.Sonar Code F1F2-4

OCEAN-BOTTOM SEISMOMETER PREPARATION AND LAUNCH DATA

Two men should prepare this list. One will make checks and readings while the other records and double-checks the first. Prepare in duplicate. One copy is to accompany tape upon recovery and the other is to be included in the Field Operations Log.

I. FINAL CHECK PRIOR TO LAUNCH

☒ 1. Battery Charging Completed

	<u>Before Drop</u>	<u>After Drop</u>		<u>Before Drop</u>	<u>After Drop</u>
B-100	<u>17.9</u>	<u>13.0</u>	B-500	<u>3.4</u>	<u>3.0</u>
B-200	<u>18.0</u>	<u>14.0</u>	B-600	<u>18.0</u>	<u>15.0</u>
B-300	<u>14.0</u>	<u>12.0</u>	B-700	<u>51.0</u>	<u>47.0</u>
B-400	<u>3.6</u>	<u>3.0</u>	B-1000	<u>18.0</u>	<u>14.5</u>

Replace CAL battery after each 30-day drop. ☒

☒ 2. Disconnect negative release wire.

☒ 3. Set and record clock release day setting.

40 ¹/₁ Digital

40 ¹/₆ ¹/₁ Bulova Back-up

☒ 4. Set and record amplifier attenuator settings.

P 24

N-S 24

V 24

E-W 21

☒ 5. Set and record calibration signal settings. Set pressure at 60 db.
Set all others 6 db lower than attenuator settings.



Ocean-Bottom Seismometer
Preparation and Launch Data
Page 2

- ☒ 6. Measure and record leakage of pressure transducer pins using Triplet meter on 100k ohm scale. Leakage should not be detectable; however a capacitive "kick" should be seen.
- ∞ Pin to ground (megohms)
- ∞ Pin to ground (megohms)
- 5 M Pin to pin (megohms) ("kick")
- ☒ 7. Measure and record leakage of antenna to ground with antenna installed.
- 5 M Pin to ground (megohms)
- ☒ 8. Tape is loaded and threaded properly, dull side up, and in good contact with heads.
- ☒ 9. Turn all switches on.
- ☒ Amp. ☒ Clock ☒ Sonar
- ☒ Xtal ☒ Recorder ☒ Transmitter
- ☒ 10. Recorder is running (if not, actuate latch relay and check end-of-tape sensor).
- ☒ 11. Transmitter is operating in pulse mode with jumper cable connected to top hemisphere.
- ☒ 12. Resistor (270 ohms) across salt water leak detector terminals actuates release system. Record voltage at release wires. Press latch relay switch on control panel to restart recorder and to regain all power. (Release voltage will be on one positive wire only.)
- ☒ 13. Resistor (1500 ohm) from antenna tip to negative release wire stops transmitter. Before disconnecting 1500 ohm resistor, connect a 15,000 ohm resistor in parallel with 1500 ohm resistor. Then remove 1500 ohm resistor. Transmitter starts again.



Ocean-Bottom Seismometer
Preparation and Launch Data
Page 3

14. Connect hydraulic test unit to transmitter pressure switch. Monitor voltage on transmitter battery lead. Transmit switch "on." Apply pressure and note gauge reading when voltage reading drops. Slowly release pressure and note gauge reading when voltage reading appears on meter. Completed during unit test
- ✓ 15. Sonar code is F₁F₂-4. Sonar test signal operates flip-flops in sonar amplifier (trig T.P.) and trips release turning off recorder and amplifier power. (Check for voltage at release wires Press latch relay reset switch to regain power to system.)
- ✓ 16. Connect output of WWV receiver to pressure channel and reset clock by WWV time while recording WWV on tape. Record WWV for sufficient time to obtain good time break for identification on tape. (Usually 1st and 4th minutes of 5-minute interval are best.)
- WWV start time 16:55 Z Date 10-21-66
- Clock reset 16:57 Z
- WWV off 17:04:10 Z
- (Reset pressure attenuator switch if changed while recording WWV.)
- ✓ 17. Check 12 volts regulated at T.P. on amplifier package and amplifier d.c. offset at each detector output. (Seis input cable should be disconnected so the amplifiers will not be overloaded.)
- ✓ 12 volts regulated 5.0 Z 5.0 N 5.0 E 5.0 P Detector d.c. volts
- ✓ 18. Reconnect seis cable and check each amplifier output at test point. Check for normal. Tap sphere or transducer itself for pressure transducer excitation.
- ✓ 19. With oscilloscope, check clock test points for:
- ✓ 400 cps at 2.2 v. p-p, approximately 2.5 millisecond repetition rate



Ocean-Bottom Seismometer
Preparation and Launch Data
Page 4

- ☒ 12 $\frac{1}{2}$ cps at 1.6 v p-p, approximately 80 millisecond repetition rate
- ☒ Time code, 2.1 v. p-p, second pulses, 1 minute between double pulses
- ☒ 20. Check bias at one of heads, approximately 1.5 volts p-p and 150 cps. (Should be good, undistorted sine wave.)
- ☒ 21. Check all wires, plugs, cables, etc. to see that all are securely fastened.
- ☒ 22. Add dessicant inside battery boxes, attach putty cup, and lower top being sure to connect beacon radio cable to control panel and to grease "O" ring and check to see that the "O" ring is seated properly in its groove.

II. SEALING OF UNIT

- ☒ 1. Draw vacuum and record
Start drop 7 (inches HG) 7 Upon recovery
- ☒ 2. Trip release spring compressed length — (inches).
- ☒ 3. Turnbuckles torqued down 25 (ft. lbs.)
- ☒ 4. Inspect roll-out hinge opposite release mechanism.
- ☒ 5. Install beacon light on unit.
- ☒ New battery installed.
- ☒ Pressure switch checked for proper operation.
- ☒ Light flashing when dropped.
- ☒ 6. Connect negative release wire.



Ocean-Bottom Seismometer
Preparation and Launch Data
Page 5

III. LAUNCH DATA

Time overboard 1822 Z Depth 800 f. Determined by Fath.
Weather Clear & Cool Sea state Calm Wind 5 K.
Location 43:00 N; 146:30 E Determined by CELESTIAL

IV. RECOVERY DATA

Recall started: Time 2200 Z Date 11-26-66
Unit surfaced 2215 Z Determined by RADIO
Unit opened: Latch relay switch pressed 0440 Z 11/27
Date 11-27-66 WWV started on P ch. 0504 Z
Time 0325 Z WWV off 0524 Z
Amplifier off 0525 Z
Clock off 0526 Z

Remarks: At drop - Skywave interference on
Loran. PINGER dropped - no positive
identification on Fathometer chart.

At recovery - both radio beacon
and light beacon operating normally.

Prepared by: Don Siebert Don Siebert

Date 10-21-66 11-27-67



APPENDIX B
OMEGA OPERATIONS REPORT



APPENDIX B

OMEGA OPERATIONS REPORT

Period from 15 November to 31 December 1966

The attached document lists non-availability times for the various OMEGA transmissions during the periods indicated. Times for OMEGA Norway are not listed for the month of November due to the fact that antenna construction was underway during this period and the station availability, as previously announced, was generally only from 2000Z to 0600Z daily.

Routine maintenance periods assigned each station are listed below. As a general rule stations are authorized down time for maintenance during these periods without notification.

OMEGA Norway	-	Saturday	0730 - 1700Z
OMEGA Trinidad	-	Sunday	1130 - 2100Z
OMEGA Hawaii	-	Sunday	2100 - 0630Z
OMEGA Forestport	-	Saturday	1700 - 0230Z

The following gross timing changes were effected during this period separate from normal synchronization procedures.

1. OMEGA Haiku - phase of transmission advanced in time 0.5 μ sec every 4 hours for 40 hours commencing November 171235Z. (This change would probably not be detected by users under normal operating circumstances.)

2. OMEGA Norway - phase of transmission advanced in time 127 μ sec December 070014Z. This would appear on continuous tracks as an advance of approximately 127 centicycles on 10.2 khz and 170 centicycles on 13.6 khz.

As a matter of interest only, the following are the general trends of errors on the indicated lines of position as measured at the OMEGA monitor site at Bermuda BWI on 10.2 khz. The results represent the effects of the synchronization process, use of the standard published skywave correction tables, predicted standards for the Bermuda site, and the instrumental accuracy of the monitor equipment.



B-D Standard Measurement Times 0615Z and 1615Z

The 1615Z error has essentially stayed close to 0 with maximum excursion to $-2 \frac{1}{2}$ CEC during the last week of December.

The 0615Z has been consistent at -10 CEC except for the period between 20-25 December when the error decreased on the average to about -6 CEC and back to -10 about 27 December. This 0 daytime and -10 to 15 nighttime appears characteristic in the East Coast operating areas as seen at Bermuda and other monitors in the Central East Coast areas.

A-D Standard Measurement Times 0445Z, 2145Z

Due apparently to ionospheric activity in the high latitudes, readings which include OMEGA Norway have shown considerable scatter on a day to day basis. Trends however are easily recognizable. Both standard time errors started at about +22 CEC early in the month decreasing to +5 on the 15th. From the 18th thru the 24th the 2145 rose slowly and is now varying slightly about +20 CEC. The 0445 error during the same period descended to -7 CEC, rose to +8 CEC on the 24th and has been varying slightly about that value ever since.

C-D Standard Measurement Times 0615, 2015Z

Both control times show the errors varying ± 5 CEC about a +10 CEC error during the entire month of December and into January.

B-C Reading derived from the B-D and C-D at 0615Z

This error stayed consistently around -16 CEC which is characteristic of the nighttime offset. On 24 December a run-off to a maximum of -25 CEC was seen. This run-off is being corrected through changes in synchronization standard numbers at OMEGA Hawaii. These changes will appear following the first of the year as a gradual advance of the phase of transmissions from that station.

NOTE: The above information is not intended to indicate the quality of the system and all effects noted do not necessarily correlate through the entire service area of the system. It is provided as a matter of interest only. As a rough rule of thumb the linear displacement of a line of position on the line joining the two transmitting stations is 500 feet per centicycle (CEC) of error or 12.4 CEC/mile.



All addressees are encouraged to correspond with the undersigned relative to any facets of operation of the system. It is expected that henceforth reports such as this containing items of general interest relative to the Research and Development efforts with the OMEGA System will be provided monthly. Anyone interested in the OMEGA Navigation System and notifying the undersigned will be placed on the distribution list.

C. G. POHLE
Systems Operation Control
OMEGA Navigation System Project Office (PM-9)



NORWAY

DECEMBER

030730-031031	Maintenance
040116-040129	Overload
081615-081620	Power Failure
090430-090525	Weather Problems
090831-090900	" "
091241-091249	Power Failure
091600-091616	Antenna Maintenance
100208-100216	Power Failure
100730-101314	Transmitter
101629-101647	Antenna Problems
101719-101724	Power Failure
102332-102339	Maintenance
121301-121527	Transmitter Failure
122306-122317	Overloads
141906-141920	Power Failure
170730-171346	Routine Maintenance
182255-182307	Antenna Maintenance
190932-191002	" "
202258-202305	Power Failure
210930-211038	Weather
240730-241105	Routine Maintenance

TRINIDAD

NOVEMBER

201130-201247	Transmitter Maintenance
282346-282359	Power Failure

DECEMBER

041130-041300	Transmitter Maintenance
172045-172115	Overload
181800-181949	Maintenance
210116-210121	Timing Failure
241406-241419	Transmitter Failure
251130-251239	Routine Maintenance



HAIKU

NOVEMBER

191114-191150

Timing Problem

DECEMBER

030145-032140

Timing Failure-periodic off air during
all this period.

091510-091528

Overload

201158-201230

Commercial Power Failure

231438-231446

Timing Problems

280542-280625

Power Failure

FORESTPORT

NOVEMBER

191700-192031

Antenna Maintenance

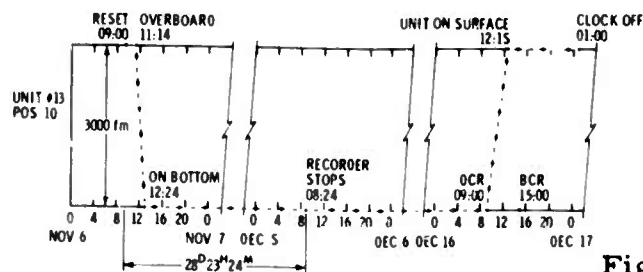
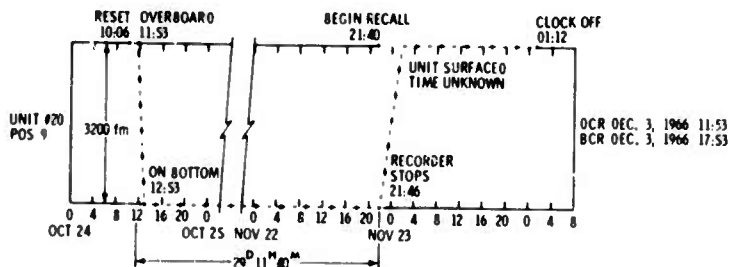
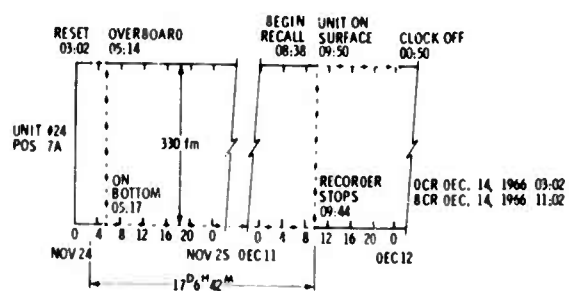
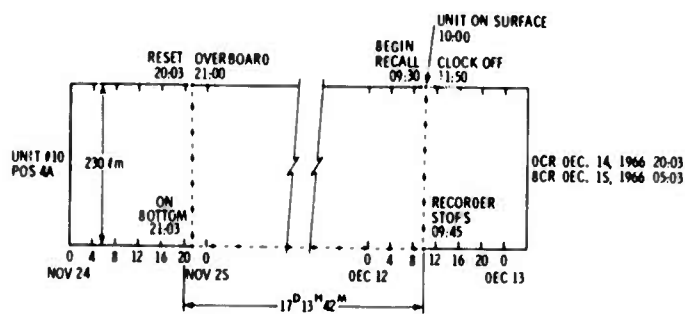
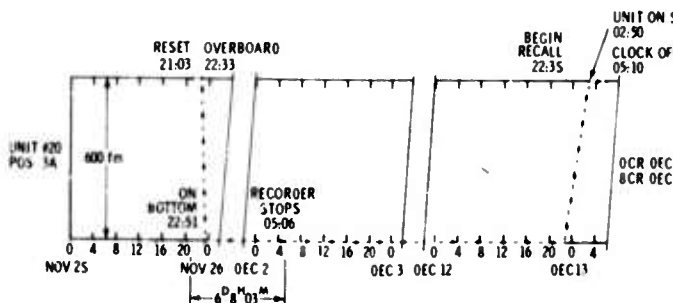
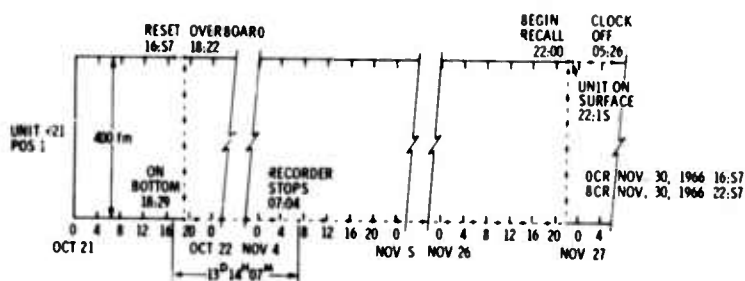
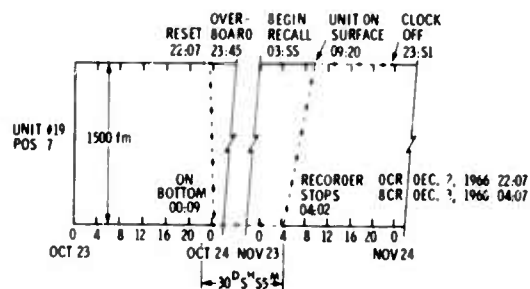
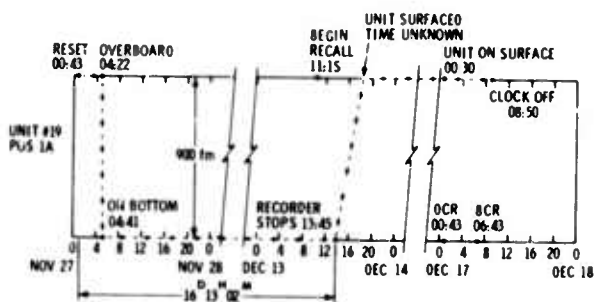
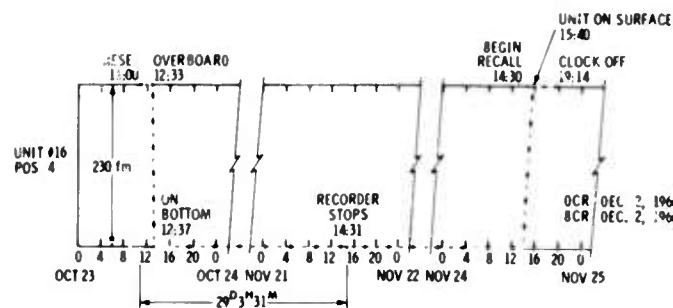
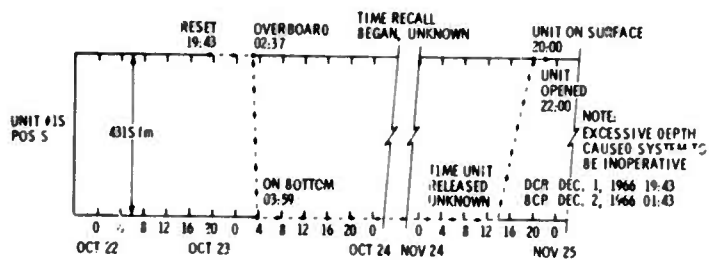
DECEMBER

None



APPENDIX C

TIME AND LOCATION OF EACH UNIT FROM RESET TO STOP



Figure

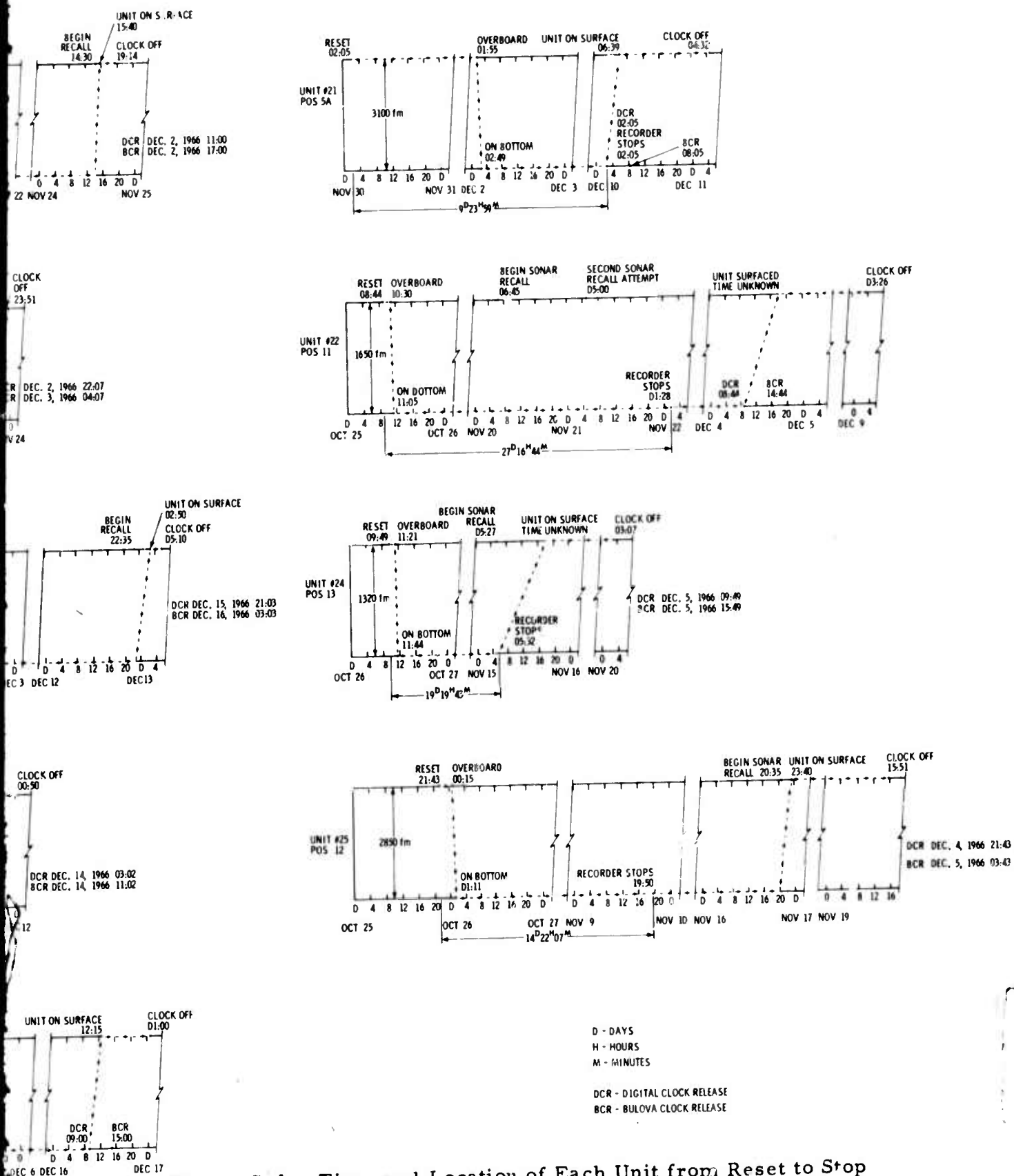


Figure C-1. Time and Location of Each Unit from Reset to Stop



APPENDIX D

**COMMUNICATIONS - O. B. SEIS KURILE EXPERIMENT
ABOARD M/V PACIFIC SEAL**



APPENDIX D

COMMUNICATIONS - O. B. SEIS KURILE EXPERIMENT ABOARD M/V PACIFIC SEAL

OBJECTIVES

- Provide for adequate communications between ships and shore agencies.
- Provide for shipboard emergencies.
- Provide for project operations
- Provide for transmission of status information

INSTALLATION

Install, test, operate, and maintain two single sideband stations capable of operation on frequencies of the stations with whom we were in communication.

EQUIPMENT

Two Collins KWM2A transceivers plus one Collins 30L1 linear amplifier were used.

Dipole antennas cut to main operating frequencies were installed between mainmast and two additional masts on the stern of the ship.

LOCATION

Communications equipment was installed in the operator's stateroom.

OPERATION

The basic channel of communication was through "Tenant," a station in the Quick Track Network. Although many channels were available, four were chosen over a frequency range which insured 24-hour coverage from all positions in our operating area.

Excellent communications were maintained during the entire period except for a few short periods when atmospheric and propagation conditions disrupted signals.

In critical periods during the calibration program and during adverse weather conditions, hourly contact was made with Tenant or other Quick Track stations to insure uninterrupted communications. Normally Tenant was monitored 24 hours per day.

As a back-up channel, use was made of MARS, the call "AF5Z" was



assigned and contact was made with Net Control AI3AF and AI1AF, AI1AH and several other MARS stations. The MARS net was used when Quick Track was busy and to handle some phone patches to continental United States (Conus).

Call signs used were

Ship's call - WO 8911

Quick Track - "Pacific Seal"

MARS - AF5Z

Arrangements were made with Kokusai Denshin Denwa Company, Ltd. (KDD) of Tokyo Marine Radio Service to handle communications through their commercial facility. Necessary crystals were obtained and two channels of the ship's radio were converted to KDD channels. Time periods were established and contact was made, but this system did not work out because of the inability to contact KDD after we left the Kushiro area.

Both the M/V Pacific Seal and M/V Campeche Seal were originally set up with this system but the ships' transceivers were converted to original configuration after the initial trip to the operating area.

Communications were maintained with:

Yakota AFB
Fuchu Weather Central
Texas Instruments Tokyo Office
American Embassy in Tokyo

Also, several phone patches to Washington, D. C. and other Conus points were successfully completed.

INTER-SHIP COMMUNICATIONS

Each ship has as standard transceiver equipment a 10-channel Raytheon 75-A-3C AM transceiver, and a RF Communications Company single sideband transceiver SB-6FA (6-channel) installed on the bridge.

The units allowed very good communications between ships about 80 percent of the time. If the ships were separated by more than 50 miles at night, communications became difficult and often impossible.

The SB6FA was also used to communicate with an aircraft in flight which was monitoring our beacon frequency.



CONSIDERATIONS FOR FUTURE OPERATIONS

Although we were able to maintain communications for a very high percentage of the time, communications were often difficult due to the low power and poor antenna system. We did have a linear amplifier aboard, but it was not always available on the channel we were trying to use.

The antenna system was a system of dipoles temporarily installed between the mainmast and two small masts near the stern. These dipoles were cut as near as possible to operating frequencies, but because of the characteristic impedance (75Ω) they would not properly match the Collins equipment (50Ω).

On future operations it would be desirable to have at least two systems equivalent to the Collins KWM2A transceiver, 30L1 Linear Amplifier, and a vertical antenna system with remote controlled tuner for each system. Complete sets of spare parts, especially tubes, should be included.

Future operations should also include a shore station manned 24 hours per day and equipped with higher power transmitter (Collins 32S1 amplifier) and a rotating beam antenna (log periodic beam).

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13 ABSTRACT <p>A shallow-water test program and a deep-water operational program were conducted. The shallow-water tests environmentally checked the performance of 14 units which were not tested under the previous contract. Special tests of antenna design and temperature measurements were included. Of the 14 units checked, 13 were either fully operational or required minor corrections. One unit surfaced prematurely, floated inshore and was damaged on the rocks. The unit is being repaired under a new contract.</p> <p>Deep-water tests were conducted adjacent to the Kurile Islands Arc to evaluate the seismicity of the area and the operational worthiness of the O. B. Seis and auxiliary equipment. Results of the seismicity study are summarized in a bulletin which is presented separately. Of 18 units dropped, 14 were recovered; of the 14 recovered, 13 recorded for all or most of the time. The one unit which did not record was dropped to a depth greater than design specifications. The great pressure permanently distorted the sphere, pushing the shell against the recorder to prevent its running. However, this unit can be repaired. In general, the auxiliary equipment performed to manufacturers' specifications. The greatest problems were caused by the weather and the area of operations.</p>		

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Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Shallow-water test program Deep-water operational program Antenna design tests Temperature measurement tests Kurile Islands Experiment Seismicity of the Kurile Islands Arc Auxiliary Equipment of O. B. Seis						

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